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Load Frequency Control using Optimal PID Controller for Non-Reheat Thermal Power System with Tcps Unit

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Abstract*—-The main objective of Load Frequency Control (LFC) is to regulate the power output of electric generator within an area, in response to the changes in system frequency and tie-line loading. Thus, LFC helps in maintaining the scheduled system frequency and tie-line power interchange with other areas within the prescribed limits. Most LFCs are primarily composed of an integral and PID controller. The integrator gain is set to a level that compromises between fast transient recovery and low overshoot in the dynamic response of the overall system. This type of controller is slow and does not allow the controller designer to consider the possible changes in operating condition and non-linearity in the generator unit. Moreover, it lacks in robustness. FACTS are designed to overcome the limitations of present non-reheat thermal-thermal power systems and enhance the power system stability. One of the promising FACTS devices is the Thyristor controlled phase shifter (TCPS) to alleviate this difficulty. TCPS is connected in the tie-line to self-tune the parameters of integral and PID controller. Two area system, have been considered for simulation of the proposed TCPS connected integral and PID controller .The performance of the Conventional controller, TCPS connected Integral and PID controller have beenCompared through MATLAB Simulation. The qualitative and quantitative comparisons have been carried out for Integral, PID controllers. The dynamic of performanceresponses of Integral and PID controller with TCPS shows that in terms of settling Time, peak overshoot and steady state error are greatly improved than that of without TCPS.

***Index Terms*— Load Frequency Control, Power system, PID controller, Thyristor controlled Phase Shifter.**

I. INTRODUCTION

Load frequency control (LFC) is a very important issue in power system with an increasing demand for electric power and more complicated. Therefore the objective of LFC of a power system is to maintain the frequency of each area and tie-line power flow (in interconnected system) within specified tolerance by adjusting the new outputs of LFC generators so as to accommodate fluctuating load demand. A number of control schemes have been employed in the design of load frequency controllers [1] in order to achieve better dynamic performance. Among the various types of load frequency controllers the most widely conventional types used are the tie-line bias control and flat frequency control to achieve the above goals of LFC, both schemes are based on the classic controls which work on same function made up of the frequency and tie-line power deviations. Nevertheless these conventional control systems have been successful to some extent only [2]. This suggests the necessity of more advanced control strategies to be incorporated for better control. In this aspect if ensuring a better power quality intelligent controllers [2-8] have been replacing conventional controllers because of their fast and good dynamic response for load frequency control problems. As the load demand increases tremendously, the power transmission over large distances to the remotely located load centres are forces to emerge into new plant for more and more effective and efficient control schemes for a better secured, reliable and stable system operation. This can be achieved by properly designed load-frequency control schemes i.e. either by the proper selection of the controller or by incorporating efficient FACTS devices. [9-12]

A Thyristor Controlled Phase Shifter (TCPS) is expected to be an effective apparatus for the tie-line power flow control of an interconnected power system In the analysis of an interconnected power system. The proposed control strategy will be a new ancillary service for the stabilization of frequency oscillations of an interconnected power system. Literature survey shows ample applications of TCPS for the improvement of dynamic and transient. Stabilities of power systems. With the use of SMES in both the areas, frequency deviations in each area are effectively suppressed. However, it may not be economically feasible to use SMES in every area of a multi-area interconnected power system. Therefore, it is advantageous if an SMES located in an area is available for the control of frequency of other interconnected areas. Further, literature survey shows that, no work has been carried out for the AGC of thermal power system considering an SMES unit. In view of this the main objectives of the present work are:

1. To develop the two area Simulink model of reheat thermal system
2. To develop the model of TCPS
3. To compare the improvement of dynamic performance

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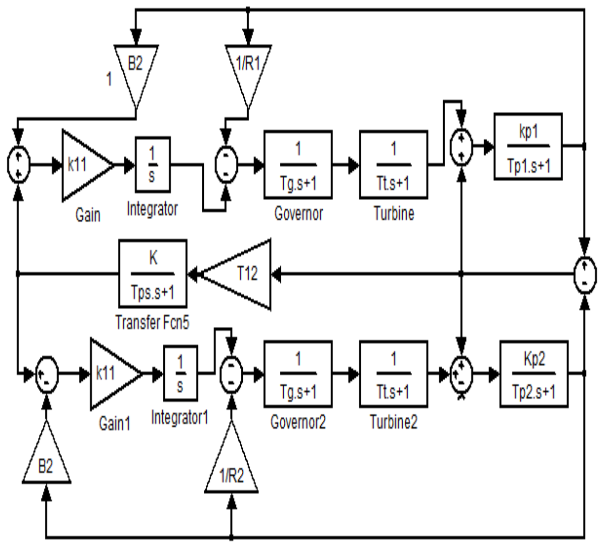


Fig:1Modeling of TCPS with Two Area Non-Reheat Thermal System.

II. TIE LINE POWER FLOW WITH TCPS

The recent advances in power electronics have led to the development of the Flexible Alternating Current Transmission Systems (FACTS). FACTS devices are designed to overcome the limitations of the present mechanically controlled power systems and enhance power system stability by using reliable and high-speed electronic devices. One of the promising FACTS devices is the Thyristor Controlled Phase Shifter (TCPS). A TCPS is a device that changes the relative phase angle between the system voltages. Therefore, the real power flow can be regulated to mitigate the frequency oscillations and enhance power system stability. In this study, a two-area of the system through TCPS and SMES hydrothermal power system interconnected by a tie line is considered.

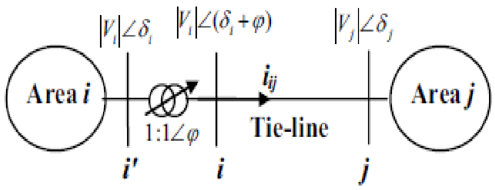


Fig 2.Interconnected two-area system with TCPS in series with tie-line

Without TCPS, the incremental tie-line power flow from Area 1 to Area 2 in a traditional system can be expressed as

$$\Delta P_{tie12}(S) = \frac{2\pi T_{12}}{s}(\Delta F_1(S) - \Delta F_2(S)) \quad (1)$$

where$T12$ is the synchronizing constant without TCPS and $\Delta F1(s)$, $\Delta F2\ (s)$ are the frequency deviations in area 1 and area 2 respectively. When a TCPS is placed in series with the tie line as in current flowing from Area 1 to Area 2 is

$$i_{12} = \frac{|V_1| < (\delta_1 + \varphi) - |V_2| < \delta_2}{jX_{12}} \quad (2)$$

And

$$P_{tie12} + jQ_{tie12} = |V_1| < (\delta_1 + \varphi)[|V_1| < (\delta_1 + \varphi) - |V_2| < \delta_2 jX_{12} \quad (3)$$

Separating the real part of Eqn. (3)

$$P_{tie12} = \frac{|V_1||V_2|}{X_{12}} \sin(\delta_1 - \delta_2 + \varphi) \quad (4)$$

But in Eqn. (4) perturbing δ1, δ2 and φfrom their nominal values and δ_1^0,φ^0respectively

$$\Delta P_{tie} = \frac{|V_1||V_2|}{X_{12}} \cos(\delta_1^0 - \delta_2^0 + \varphi^0)\sin(\Delta\delta_1 - \Delta\delta_2 + \Delta\varphi) \quad (5)$$

But for a small change in real power load, the variation of bus voltage angles and also the variation of TCPS phase angle are very small. As a result (Δδ1-Δδ 2+Δφ) is very small and hence,

Sin (Δδ 1- Δδ2 +Δφ)≈(Δδ 1 -Δδ2 +Δφ). So Eqn. (5) can be written as

$$\Delta P_{tie12} = \frac{|V_1||V_2|}{X_{12}} \cos(\delta_1^0 - \delta_2^0 + \varphi^0)(\Delta\delta_1 - \Delta\delta_2 + \Delta\varphi) \quad (6)$$

$$\Delta P_{tie12} = T'_{12}(\Delta\delta_1 - \Delta\delta_2 + \Delta\varphi) \quad (7)$$

Where $T'_{12} = \frac{|V_1||V_2|}{X_{12}} \cos(\delta_1^0 - \delta_2^0 + \varphi^0)$ (8)

$$\Delta P_{tie12} = T'_{12}(\Delta\delta_1 - \Delta\delta_2) + T'_{12}\Delta\varphi \quad (9)$$

But $\Delta\delta_1 = 2\pi \int \Delta f_1 dt \ \ and \ \ \Delta\delta_2 = 2\pi \int \Delta f_2 dt$ (10)

Eqn. (9) can be modified as

$$\Delta P_{tie12}(S) = 2\pi T'_{12}(\Delta f_1 dt - \Delta f_2 dt) + T'_{12}\Delta\varphi \quad (11)$$

The Laplace transform of Eqn (11) is

$$\Delta P_{tie12}(S) = \frac{2\pi T'_{12}}{s}[\Delta F_1(S) - \Delta F_2(S)] + T'_{12}\Delta\varphi(S) \quad (12)$$

As per Eqn. (12), it can be observed that the tie-line power flow can be controlled by controlling the phase shifter angle Δφ. Assuming that the control input signal to the TCPS damping controller is $\Delta Error1(s)$ and that the transfer function of the signaling conditioning circuit is $K_\varphi C\ (s)$, where $K_\varphi$is the gain of the TCPS controller

$$\Delta\varphi(S) = K_\varphi C(S)\Delta Error_1(S) \quad (13)$$

$$C(S) = \frac{1}{1+sT_{ps}} \quad (14)$$

The phase shifter angle $\Delta\varphi$(s) can be written as

$$\Delta\varphi(S) = \frac{K_\varphi}{1+sT_{PS}}\Delta Error_1(S) \quad (15)$$

$$\Delta P_{tie12}(S) = \frac{2\pi T'_{12}}{s}[\Delta F_1(S) - \Delta F_2(S)] + T'_{12}\frac{K_\varphi}{1+sT_{PS}}\Delta Error_1(S) \quad (16)$$

Where $K_\varphi$and Tps are the gain and time constants of the TCPS and $\Delta Error1(s)$ is the control signal which controls the phase angle of the phase shifter.

III. LOGIC OFTCPS CONTROL STRATEGY

$\Delta Error1$ can be any signal such as the thermal area frequency deviation $\Delta f1$or frequency deviation $\Delta f2$ or ACE of the thermal or other area to the TCPS unit to control the TCPS phase shifter angle which in turn controls the tie-line power flow. Thus, with $\Delta Error1=\Delta f1$, Eqn (13) can be written as

$$\Delta\varphi(s) = \frac{K_\varphi}{1+sT_{ps}}\Delta F_1(s) \qquad (17)$$

The above logic can be demonstrated as follows

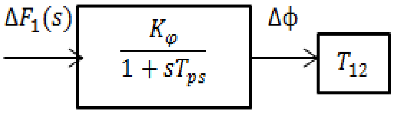


Fig 3.Logic of TCPS in series with tie line

IV. IV.PROBLEM STATEMENT

Designing PID controller, even for non-linear plantssuch as power system, can be a difficult problem. Consider the system where the PIDcontroller obey the following control law:

$$M(s) = (K_p + \frac{K_i}{s} + K_d s)E(s) \qquad (1)$$

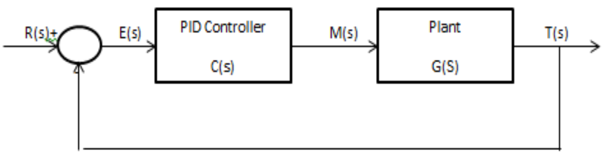
where$k\ p$, ki and kd are proportional, integral, and derivative gains, respectively.

The objective of PID controller design is to determine aset of gains ($k\,p$, ki and kd) of the control law such thatthe set of roots of the characteristic equation chosen bythe designer are obtained. The three gain parameters ofthe PID control law interact with the plant parameters(s) in a complex fashion when the designer attempts toobtain the specified roots of the characteristic equation. These roots are chosen in order to obtain the desired transient response of the closed loop, while taking the resultant zeros into account. PID controller increase the order of the characteristic equation by one. The controller introduces a new pole at original of the s-plane, and they shift the original compensated root of the closed loop system to new positions on s-plane, In addition to these effects, PID controllers introduce a pair of zeros, usually a complex conjugate pair, which will normally have insignificant effect on the transient behavior of the compensated system.

The efficiency of the system can be measured bycalculating the integral of multiplied by the error for theunit step response during [0,T]:

$$Error = \int_0^T t|e(t)|dt \qquad (2)$$

The problem confronting the designer, therefore, is tocalculate the three gains of the PID controller whileensuring that transient response (minimum error,overshoot, rising time, settling time and steady-stateerror) specification are met.



V. SIMULATION RESULTS

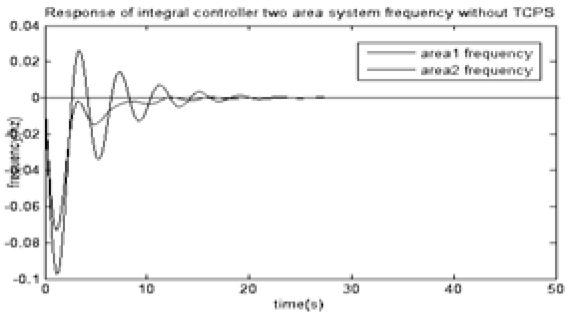


Fig4. Response of integral controller frequency without TCPS

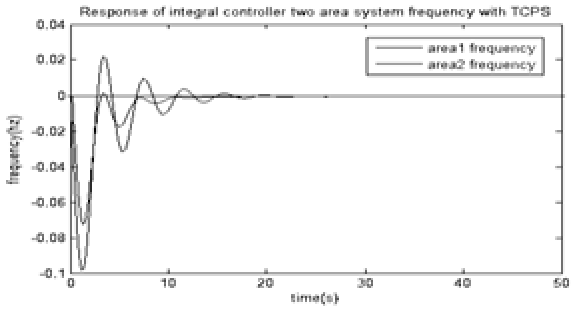


Fig5.Response of integral controller frequency with TCPS

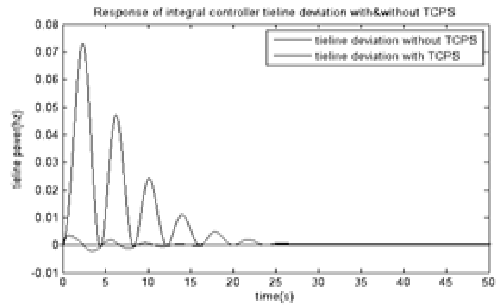


Fig6.Response of tie-line power deviations with & without TCPS

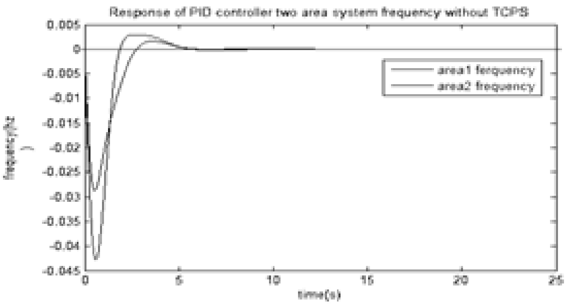


Fig7.Response of PID controller two area system frequency

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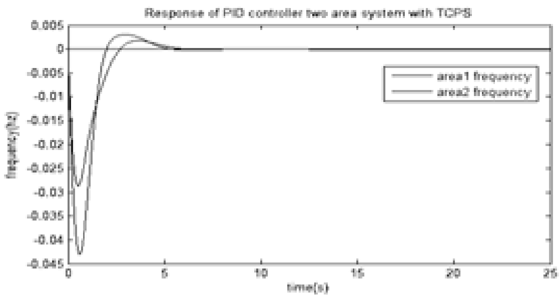

Fig8.Response of PID controller two area system frequency with TCPS

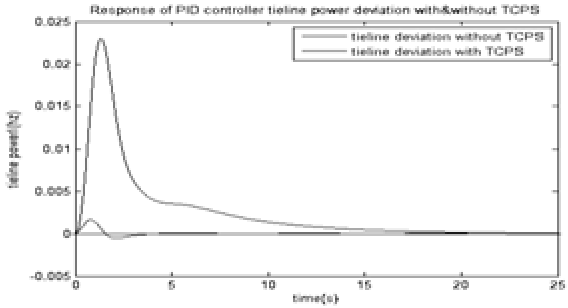

Fig: 9 Response of PID controller tie-line power deviations with & without TCPS

VI. CONCLUSION

The performance of a two area interconnected thermal non-reheat system is investigated using integral and PID controllers. The integral & PID controller gains with and without operation of TCPS units have been optimized. The dynamic responses of with and without TCPS has been compared as both controllers, we conclude that the TCPS operation is very effective in wiping out oscillatory in area frequencies (i.e. area1 & area2) and tie-line power oscillations following momentary deflections in the load, improving performance of LFC of interconnected power systems. The PID controller responses are superiority performance than the integral controller with a operation of TCPS in both areas and tie-line power oscillations. The PID controller gives less overshoot, settling time & tie-line power oscillations than the integral controller for non-reheat thermal turbine in the two area thermal system. The responses are compared both qualitatively and quantitatively with the TCPS operation in both controllers; it effectively reduces the power oscillations and improving the performance of the interconnected area power systems.

REFERENCES

1. N.Jaleeli, d.N.Ewart, and L.H.Fink, Aug 2008'understanding Automatic Generation Control' IEEE Trans.Power System Volume 7, no. 3, PP 1106-1122
2. Hadi Sadat Power system analysis Tata McGraw –hill publishing company ltd-New Delhi
3. O.I.Elgered, McGraw-Hill, NewYork1982'Electric Energy System theory', An Introduction
4. T.Hiyama, 2009, 17-22 'design Of Decentralized Load Frequency Regulators for Interconnected Power System IEEE Proceedings on Generation, transmission distribution' 129
5. A.Bose&I.Atiyyah, 2004, 650-657, PAS-99' Regulation error in load frequency control', IEEE trans on power apparatus and systems
6. K.Xing&G.Kusic,'Application of Thyristor controlled Phase Shifters to minimize real power losses and argument stability of power Systems,IEEE trans on Energy Conversion,3,2009,792-798
7. R.J.Abraham, D.Das & A.Patra, IET Generation Transmission and distribution, 1(4), 2007, 632-639,'effect of TCPS on oscillations in tie-power and area frequencies in an interconnected thermal power system'
8. M.H.Ali, Wubin & R.A.Dougal,'an overview of SMES application in power and energy Systems', IEEE transactions on sustainable energy1 (1), 2010, 38-47
9. H.Hayashi, Y.Hatabe, T.Nagfuchi, at al test results of power system control byExperimental SMES, IEEE transaction on applied superconductivity 16(2), 2006, 598-601

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